4 Characterization of the Ozone Weekend Effect in California

4.2 The Weekend Ozone Effect During Ozone-Conducive Days in the South Coast Air Basin

Abstract/summary

With ozone known to be higher during the weekends compared to weekdays at many sites in the South Coast Air Basin, this study attempts to investigate whether the basinwide maximum 1-hour daily concentrations behave differently on days considered highly conducive for ozone formation as compared to all days. Using meteorology to predict ozone, we classify approximately one-third of the days during May through October of 1992-1994 and 1996-1998 to be highly conducive and compare the day-of-week pattern of mean ozone concentrations adjusted for trend and seasonality. Preliminary results show the basinwide maximum ozone to behave similarly during the weekend on all days and highly ozone-conducive days – increasing from Friday to Saturday, remaining almost the same on Sunday, then decreasing on Monday. Approximate confidence intervals indicate strong evidence of this “weekend effect” for all days. However, for highly ozone-conducive days, the available data and methods do not sufficiently resolve differences between days of the week.

4.2.1 Introduction/background

Austin and Tran (1999) characterized the behavior of ambient ozone concentrations in three metropolitan regions of California. That work considered all days during the ozone season and clearly shows ozone to significantly increase during the weekend and decrease at the start of the weekdays at many sites. In this chapter, we attempt to describe the weekend effect of ozone in the South Coast Air Basin during ozone-conducive days. Further, we evaluate whether ozone behaves differently than it does when analyzed across all days.

4.2.2 Methodology

We consider the basinwide daily 1-hour maximum ozone concentrations during two periods around the Cleaner-Burning Gasoline (CBG) program: 1992-1994 (pre-CBG) and 1996-1998 (post-CBG). Wherever possible, we follow the methods used in Austin and Tran (1999).

To remove nuisance sources of variation, we fit a smoothed (spline) line to basinwide ozone maximum concentration from all days (365 days in each year) and obtain

adjusted (residual) concentrations by subtracting smoothed values from observed concentrations.

Next, we isolate only ozone season, May 17 – October 15, and compute the mean adjusted (residual) concentrations by day of week (DOW) for all days in the ozone season. This information will be considered as the base ozone behavior for all days.

To assess ozone-conduciveness, we use Lawrence C. Larsen's equations (1998) for predicting basinwide daily 1-hr max ozone based on meteorological conditions in the basin (surface and aloft temperatures). Since these equations were developed for basinwide maximum concentrations, our results could not be compared directly with previous work on site-specific DOW patterns (Austin and Tran, 1999).

Next, we stratify days into three groups of ozone-conducive levels based on predicted ozone: Low (<= 0.12 ppm), Medium (>0.12 ppm but <= 0.16 ppm) , and High (> 0.16 ppm). This stratification results in approximately equal number of data points in each group.

Similar to the analysis of All Days, we compute the mean adjusted ambient concentrations by DOW for each group. In contrast to the percent changes in concentration from day to day done in Austin and Tran (1999), these means are intended for comparing patterns rather than testing for statistical significance. Hence, only approximate confidence intervals are computed.

To assist us in comparing patterns of ozone behavior, we plot the means between groups, across All Days, and between pre-CBG vs post-CBG periods.

4.2.3 Results/discussion

4.2.3.1 About tables and figures

Table 1 lists the mean residual concentrations and their standard deviations for each of the 4 categories in the pre-CBG period: High, Low, Medium and All Days. Table 2 lists similar information for the post-CBG period.

Figure 1 is a scatterplot of the basinwide daily maximum 1-hour ozone concentration in the pre-CBG period, with the "smoothed" line superimposed. Figure 2 displays similar information for the post-CBG period.

Figure 3 displays the means from Table 1 in graphical form. Figure 4 displays those from Table 2.

Figure 5 displays the approximate 90% confidence intervals around the DOW means from Table 1 for the High group and All Days. Figure 6 displays similar info from Table 2.

4.2.3.2 1992-1994 Results

In the pre-CBG period, the Low and High groups show ozone to decrease from Thursday to Friday and to increase similarly on Saturday and Sunday. But for the Medium group, ozone increases from Thursday to Friday, followed by a steep increase on Saturday and a decrease on Sunday.

4.2.3.3 1996-1998 Results

In the post-CBG period, the Low group shows ozone to increase from Thursday to Friday, followed by increases on Saturday and Sunday – as in the pre-CBG period. For the Medium group, ozone decreases from Thursday to Friday, then followed by a weekend behavior similar to pre-CBG period. For the High group, ozone decreases from Saturday to Sunday in post-CBG period; it increases in the pre-CBG period.

4.2.3.4 Results for High ozone-conducive days

During High ozone-conducive days in both periods, ozone tends to rise during the week to a peak on Thursday, then decreases on Friday before exhibiting the typical weekend pattern. Whether this increase on Thursday is significant requires further investigation.

Overall, we see the weekend pattern for the High group is similar to that across All Days, unlike the Medium group. That is, in both periods, the typical weekend pattern of ozone -- increasing from Friday to Saturday, remaining almost the same on Sunday, then decreasing from Sunday to Monday – exists in High ozone-conducive days as well as All Days.

Whereas in Austin & Tran (1999), Sunday ozone was highest compared to other days after CBG for many sites, the “Sunday effect” does not exist in basinwide maximum for the High group.

4.2.3.5 On approximate statistical significance

Note that no formal statistical significance testing was conducted; the focus is on estimation rather than inference. Tables 1 & 2 indicate standard errors (standard deviations of the mean) approximately equal to 0.007 ppm for High group and 0.004 ppm for All Days. These standard errors lead to the computation of approximate confidence intervals for each mean. However, a formal test for significant differences between days would need to account for the correlation between days rather than assuming independence. Since the correlation is positive, the standard errors in Table 1 & 2 are greater than they would be if the correlation were correctly removed from the data. Nevertheless, approximate confidence intervals may give us further insight.

Figures 5 and 6 display approximate 90% confidence intervals for the mean ozone residual concentrations by DOW in the pre-CBG and post-CBG periods, respectively. When the bars do not overlap, there is strong evidence of a significant difference between days. On the other hand, if they do overlap, it does not imply that the DOW

means are “the same”. The available data combined with our current methods may not be able to resolve any differences clearly.

Based on the approximate intervals in Figures 5 and 6, we can see that the weekend effect strongly exists for All Days in both periods, with Friday increasing to Saturday and Sunday decreasing to Monday (and no significant differences between weekdays). The evidence for a weekend effect is not as clear in the High group; no one day is significantly different from the others.

4.2.4 Conclusion/implication

The weekend pattern for basinwide daily 1-hour maximum concentrations appears to be similar for all days combined and for highly ozone-conducive days. In other words, the weekend effect is not “exacerbated” or “intensified” under ozone-conducive conditions in the SoCAB.

A rough look at the approximate confidence intervals indicates strong evidence of the weekend effect for all days. The available data combined with our current methods do not sufficiently resolve differences in basinwide maximum ozone concentrations between days of the week on highly ozone-conducive days.

4.2.5 Recommendation

The results from this study are based on approximate confidence intervals. A more careful investigation that accounts for all sources of variation in the data would warrant more definitive conclusions. Other methods of determining ozone-conduciveness could also be explored.

4.2.6 References

Austin, J. and H. Tran (1999) “A characterization of weekday-weekend ambient ozone concentrations in California,” *Proceedings of the 7th International Conference on Air Pollution*, July 27-29, Palo Alto, California.

Lawrence C. Larsen (1998) “Cleaner-Burning Gasoline: An Assessment of Its Impact on Ozone Air Quality in California”, January.

Table 4.2.1. Mean residual ozone concentrations, 1992-1994.

1992-94 Group	Day of Week	No. of Observations	Mean Residual Concentration	Standard Deviation of Mean
High	Sunday	24	0.0292	0.0069
High	Monday	21	0.0223	0.0071
High	Tuesday	22	0.0084	0.0068
High	Weds.	24	0.0194	0.0071
High	Thursday	23	0.0289	0.0077
High	Friday	27	0.0175	0.0090
High	Saturday	24	0.0265	0.0095
Low	Sunday	28	-0.0113	0.0087
Low	Monday	28	-0.0275	0.0067
Low	Tuesday	26	-0.0266	0.0052
Low	Weds.	27	-0.0246	0.0062
Low	Thursday	28	-0.0215	0.0053
Low	Friday	21	-0.0270	0.0058
Low	Saturday	24	-0.0160	0.0071
Medium	Sunday	22	0.0054	0.0085
Medium	Monday	25	-0.0111	0.0082
Medium	Tuesday	26	-0.0104	0.0060
Medium	Weds.	23	-0.0029	0.0062
Medium	Thursday	23	-0.0065	0.0057
Medium	Friday	26	-0.0027	0.0052
Medium	Saturday	26	0.0267	0.0078
All Days	Sunday	74	0.0068	0.0051
All Days	Monday	74	-0.0078	0.0048
All Days	Tuesday	74	-0.0105	0.0038
All Days	Weds.	74	-0.0036	0.0043
All Days	Thursday	74	-0.0012	0.0043
All Days	Friday	74	-0.0022	0.0046
All Days	Saturday	74	0.0128	0.0052

Table 4.2.2. Mean residual ozone concentrations, 1996-1998.

1996-98 Group	Day of Week	No. of Observations	Mean Residual Concentration	Standard Deviation of Mean
High	Sunday	25	0.0246	0.0070
High	Monday	22	0.0027	0.0055
High	Tuesday	25	0.0121	0.0056
High	Weds.	24	0.0200	0.0063
High	Thursday	22	0.0244	0.0077
High	Friday	23	0.0112	0.0056
High	Saturday	22	0.0275	0.0054
Low	Sunday	27	-0.0036	0.0041
Low	Monday	31	-0.0154	0.0037
Low	Tuesday	27	-0.0164	0.0036
Low	Weds.	27	-0.0139	0.0044
Low	Thursday	31	-0.0167	0.0047
Low	Friday	29	-0.0137	0.0045
Low	Saturday	26	-0.0119	0.0045
Medium	Sunday	22	0.0079	0.0062
Medium	Monday	21	-0.0047	0.0044
Medium	Tuesday	22	-0.0119	0.0056
Medium	Weds.	23	-0.0103	0.0055
Medium	Thursday	21	-0.0035	0.0049
Medium	Friday	22	-0.0076	0.0049
Medium	Saturday	26	0.0134	0.0052
All Days	Sunday	74	0.0094	0.0036
All Days	Monday	74	-0.0070	0.0027
All Days	Tuesday	74	-0.0055	0.0032
All Days	Weds.	74	-0.0018	0.0035
All Days	Thursday	74	-0.0007	0.0038
All Days	Friday	74	-0.0041	0.0031
All Days	Saturday	74	0.0087	0.0034

Figure 4.2.1. Basinwide daily maximum 1-hour ozone (in ppm), 1992-94, with smoothed line superimposed.

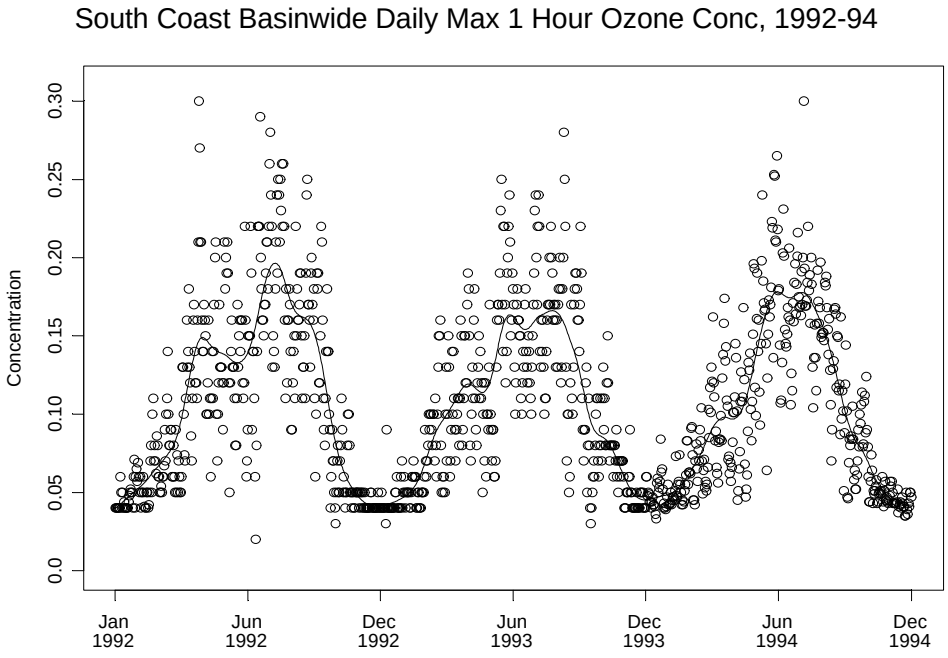

Figure 4.2.2. Basinwide daily maximum 1-hour ozone (in ppm), 1996-98, with smoothed line superimposed.

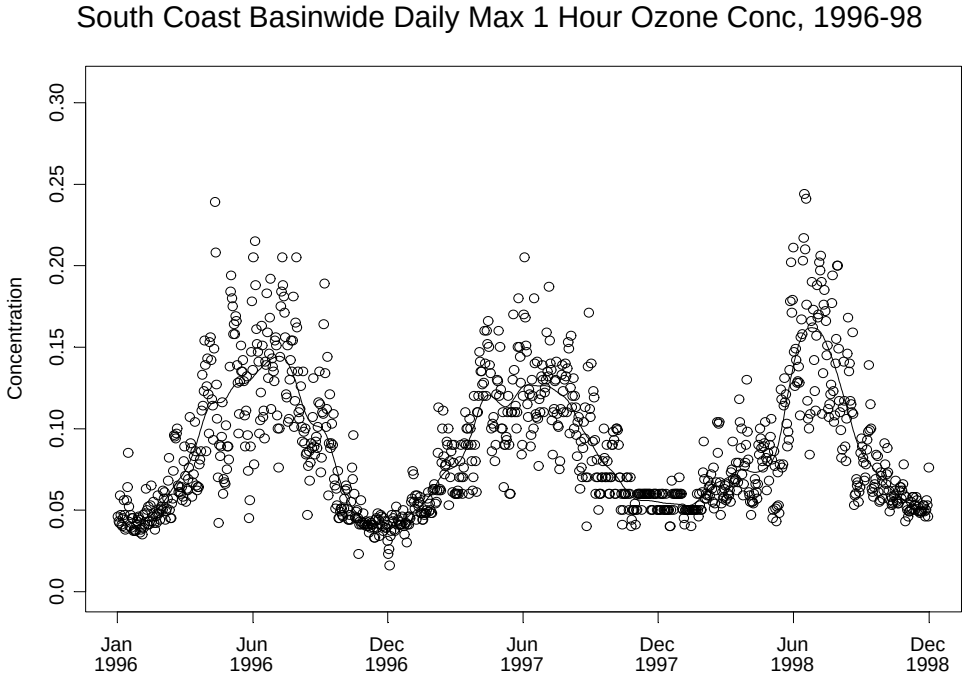

Figure 4.2.3. Mean residual ozone concentrations by day of week, 1992-1994.

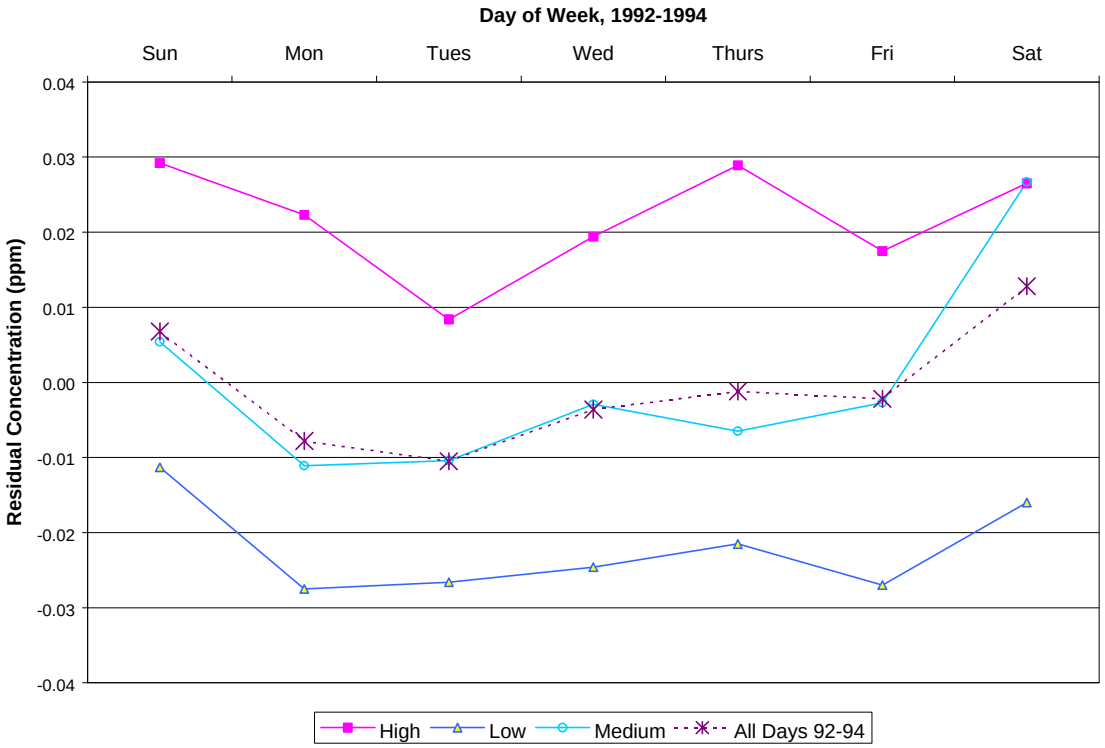

Figure 4.2.4. Mean residual ozone concentrations by day of week, 1996-1998.

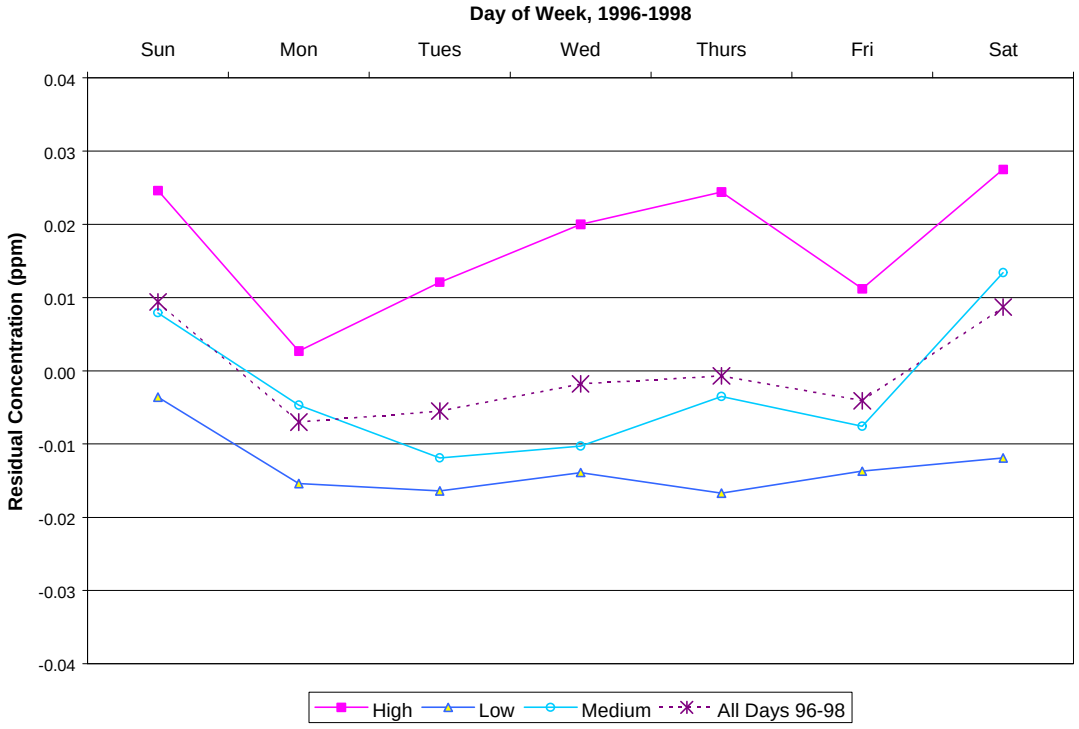

Figure 4.2.5. Approximate 90% confidence intervals for mean residual ozone concentrations on highly ozone-conducive days and all days combined, 1992-94.

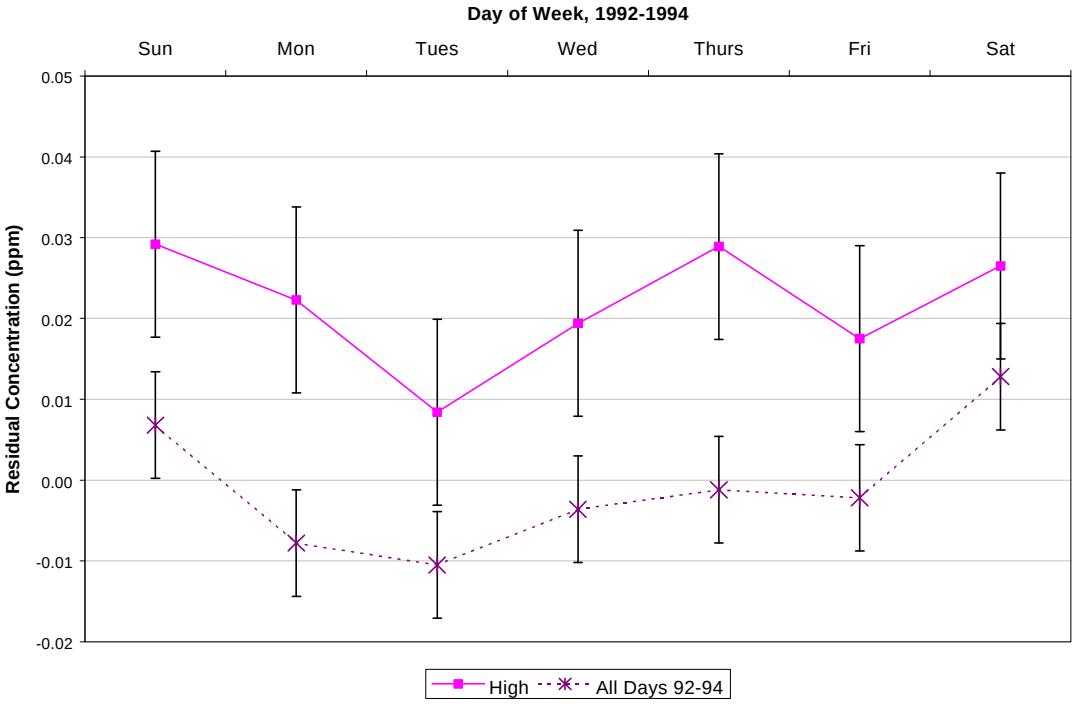

Figure 4.2.6. Approximate 90% confidence intervals for mean residual ozone concentrations on highly ozone-conducive days and all days combined, 1996-98.